Introduction: The purpose of this study was to evaluate a novel resurfacing technique employing a metal implant for the repair of large full thickness cartilage defects in the medial femoral condyle (MFC) of goats. Osteochondral (OC) defects are frequently encountered in the human knee of osteoarthrosis patients. Spontaneous regeneration of hyaline cartilage in large defects is unattainable and surgical abrasion, drilling, or debridement prompts, at best, only fibrocartilage formation. Healing using autografts or allografts is unpredictable and cytokine, cell or gene therapies are not fully proven. Uni- or multi-compartmental arthroplasty is frequently the procedure of final resort.

Goats have previously been used to evaluate techniques for eliciting articular cartilage repair. Their compliant behavior, large size, and joint anatomy is advantageous when testing orthopedic devices intended for application in humans. In a previous study, untreated full-thickness 6 mm diameter OC defects of the caprine MFC failed to heal. Large cavitory lesions formed at the defect site and the adjacent subchondral bone and articular cartilage collapsed. We hypothesize that surgical treatment of similarly sized osteochondral defects using an anchor-based press-fit Co-Cr alloy resurfacing implant will provide an enhanced outcome characterized by minimal joint pathology and improved range of motion and clinical soundness.

Materials and Methods: The study was approved by the Institutional Animal Care and Use Committee. Six healthy castrated male Nubian goats, aged 3 years and weighing 60-80 kg, underwent general anesthesia. The MFC of one limb only was surgically exposed via an arthrotomy. Under fluorescent guidance a 1.5 mm diameter guide wire was implanted tangential to the central weight bearing articular surface of the MFC. A 4.5 mm diameter cannulated drill bit, placed over the guide wire, was used to create a 20 mm deep pilot hole. The guide wire was removed and the pilot hole was tapped and then implanted with an 20 mm long recessed titanium alloy anchoring screw. The contour of the articular surface at the implant site was mapped and a full thickness 11 mm diameter cartilage defect, extending into the subchondral bone, was created. Finally, a pre-fabricated Co-Cr alloy resurfacing implant, matching the articular contour, was press-fitted into the defect. The joint was lavaged with 0.9% saline and overlying soft tissues were routinely closed. Goats were administered perioperative ceftiofur Na antibiotic and buprenorphine and phenylbutazone analgesics. Goats 1-3 were re-anesthetized at post-operative week (POW) 14 for arthroscopic re-evaluation of the operated joint. They were then maintained out to POW 26 at which time they were euthanatized. Goats 4-6, who received only the implantation surgery, were maintained out to POW 52. Goats received no post-operative limb immobilization but were still confined for POWs 0-12 and 14-18. They otherwise received communal pasture exercise for 8 hours each day. Response to implantation was assessed by daily observation of each animal, weekly complete physical examination, bi-weekly lameness evaluation, pre-anesthetic and pre-mortem hematologic and blood chemistry profiles, and pre-mortem arthrocentesis. Radiographs of the operated and contralateral unoperated joints were visually examined for gross pathology and implant status. Articular soft tissues were recovered for histologic examination (H&E). The operated and unoperated joints were visually examined for gross pathology and implant status. Articular soft tissues were recovered for histologic examination (H&E). The operated and unoperated joints were visually examined for gross pathology and implant status. Articular soft tissues were recovered for histologic examination (H&E). The operated and unoperated joints were visually examined for gross pathology and implant status. Articular soft tissues were recovered for histologic examination (H&E).

Results: The surgical instrumentation and technique allowed for accurate and effective positioning of appropriately contoured resurfacing implants in all 6 goats. This was grossly characterized by a surface continuum between cartilage and adjacent implant throughout much of their interface with only occasional recessing of the implant below the cartilage surface by <0.5 mm. The implants, as judged by gross, histologic and radiographic examination, remained securely fixed at the defect site throughout the study period. All 6 goats were moderately lame on the operated limb for the first 48 hours post implantation but by POW 3 only a mild occasional lameness was discernable, no joint effusion or instability was apparent, and range of motion remained unrestricted. This characterization persisted through the study period with the exception of immediately post-arthroscopy in goats 1-3. Pasture exercise was characterized as uninhibited and effective in all 6 goats through the duration of the study. Arthroscopic re-evaluation of goats 1-3 at POW 14 revealed mild (goats 1 and 3) or moderate (goat 2) villous inflammation. The interface between cartilage and implant, viewed using digital magnification of the arthroscopic image, was characterized by segments of i) smooth cartilage elevated or depressed ~0.5 mm above or below the implant surface respectively, and ii) partial thickness smooth or moderately irregular cartilage flowing ~1.0 mm over the implant surface. No tibial plateau or meniscal abnormalities were noted. Radiographs taken at POW 14 revealed marginal smooth exostosis formation along the medial border of the MFC of the operated limb. These excrescences persisted through the study period.

Discussion: The novel surgical procedure evaluated in this long term study provided successful stable fixation of anatomically correct contoured resurfacing implants in OC defects of caprine MFCs. All 6 goats retained excellent range of motion in the operated joint and a very acceptable level of clinical soundness. Although mild chronic inflammation was documented, the extent of pathologic change was much reduced over that encountered in a previous study of similarly sized MFC OC defects left untreated. Bone remodeling along the medial margin of the operated MFC and the elevated synovial fluid protein encountered in the unoperated as well as operated joints imply that hind limb gait kinematics change substantially (enough to cause remodeling) but subtly (causing minimal lameness) in response to the surgical procedure.

Grade IV (exposed bone) cartilage injury is a frequent cause of chronic knee pain. In one series, 20% of the 31,516 human knees that underwent arthroscopic evaluation were afflicted with this lesion. A substantial subset of these patients are eventually managed by arthroplasty, sometimes in middle age (30-50 years) in which case revision procedures may become necessary. Our initial data imply that the comparatively less traumatic resurfacing technique described here may serve as a bridging treatment for these patients, possibly ameliorating the inflammation and pain of osteoarthrosis, and thereby delaying or obviating the need for major arthroplasty.


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